Arkwood, Inc., Superfund Site
Comments on Draft Supplemental Groundwater Tracing Summary Report dated March 2015

Item No.	Reference	EPA Comments Dated October 9, 2015	PRP Response
1.	Supplemental Groundwater Tracing Summary Report General	The maps and figures used to identify the site and important sampling locations can be improved. Generation of water-level maps (water table and potentiometric) would help with identifying pathways. All receptors (other adjacent withdrawal wells) should be identified on maps.	
2.	Supplemental Groundwater Tracing Summary Report General	Less than 50% of the dye was recovered/detected at sample locations. It is speculative to assume that an equivalent amount of dye or greater was retained in non-mobile volume of the rock. Another scenario is that all pathways were not determined and some deep underflow occurs.	
3.	Supplemental Groundwater Tracing Summary Report Section 1.3 Hydrogeologic Setting Page 4.	The report states, "The semi-quantitative dye tracing investigation discussed in this report provides a valuable on-Site measurement of the percent of mobile porosity existing in the most impacted portion of the shallow epikarstic zone aquifer at the Arkwood Site." The report does not provide the procedures used to estimate the percent mobile porosity based on the results of the tracer tests. The report should be revised to include this information.	
4.	Supplemental Groundwater Tracing Summary Report Section 1.4 Previous Groundwater Tracing Study	The report states that one trace was introduced at the "woodchip pile" at the southeast corner of the site, and that "The 1991 tracing demonstrated that the Site was underlain by a groundwater divide. Groundwater from the southeastern portion of the Site discharges to the Walnut Creek topographic basin and groundwater from the northwestern portion of the Site discharges to the Cricket Creek topographic basin." This is an	

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	Page 5	important aspect of the tracer study, and it relates to the overall feasibility of the New Cricket Spring to fully capture contaminated ground water at the Arkwood site. Multiple lines of evidence are consistent with a ground water flow divide hydrologic conceptual model. Therefore, the on-site multi-directional contaminated ground water flow directions, particularly at high spring discharge rates (i.e., "peak flows") are unlikely to be captured by the New Cricket Spring located off-site on the west side of the facility. Given this preliminary assessment of the data and information, it appears unlikely that capture of all the contaminated ground water by New Cricket Spring has been attained. It would be worthwhile to re-evaluate the ability of the New Cricket Spring ground water treatment system to fully capture all of the contaminated ground water emanating from the area encompassed by the Arkwood site.	
5.	Supplemental Groundwater Tracing Summary Report Section 2.2.1 Types of Samples Page 8	The report states, "Composite water samples were collected to permit a mass balance calculation for each tracer dye. This information permits a measurement of the percent of mobile porosity in the portion of the epikarstic aquifer lying between the former sinkhole and New Cricket Spring." The report should specify what calculations were used to estimate "mobile porosity."	

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6.	Supplemental Groundwater Tracing Summary Report Table 5 Page 9	Please label the injection wells.	
7.	Supplemental Groundwater Tracing Summary Report Figure 1 Page 10	City water location #18 is missing on the map. Please label the springs.	
8.	Supplemental Groundwater Tracing Summary Report Section 2.3 Laboratory Analyses Page 12 Appendix A Page A-7	The report states, "Activated carbon samples were rinsed under a relatively strong jet of water, eluted in a standard eluting solution. Water samples were pH adjusted to raise the pH of the water to 9.5 or higher." Appendix A indicates the elution solution is typically comprised of an alcohol, water, and a strong basic solution such as aqueous ammonia and/or potassium hydroxide. Information should be provided regarding the extent to which a mass balance could be achieved in the complete removal of the dyes from the carbon as a control sample.	
9.	Supplemental Groundwater Tracing Summary Report Table 8	A runoff rate per area would be helpful to assess whether underflow is occurring at the weir.	

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10.	Supplemental Groundwater Tracing Summary Report Tables 9 through 11 Pages 16 through 19	Including travel times in the table would be helpful.	
11.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22 Second paragraph	The report states, "The technical literature suggests that dye traces from sinkholes to springs are typically characterized by 20 to 50% of the introduced dye being detected at the receiving spring (Aley1997). The detection percentages from this study are within the reported range." The potential array of possible testing conditions that could occur for a specific tracer test is broad and dependent on many site variables. Therefore, it does not seem prudent that the range of recovery reported (20-50%) should serve as a quality assurance or quality control metric. An analysis to quantify the immobile porosity should be provided to support this point, if this point is to be considered valid.	
12.	Supplemental Groundwater Tracing Summary Report	The report states, "The detection percents for the two dye traces (45% for fluorescein and 38% for rhodamine WT) provide a measure of mobile porosity in the most contaminated portion of the groundwater system at the Arkwood Site."	

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	Section 3.3.2 Mass Balance Calculations Page 22 Third paragraph	Please clarify how the mobile porosity was calculated from the dye tracer test results.	
13.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22 Third paragraph	The report indicates the dye that was not recovered was detained within the non-mobile portion of the epikarstic aquifer. An additional tracer fate mechanism that was not investigated or discussed involves the transport of the tracer beyond the capture zone of the New Cricket Spring. Specifically, under this condition the tracers would bypass the capture zone of the spring. Please clarify why it was inferred that the unrecovered dye did not simply bypass the New Cricket Spring.	
14.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22	The report seems to conclude that all pathways have been identified and, therefore, the amount of dye recovered is a function of mobile and immobile porosity, but this is not stated or supported.	
15.	Supplemental Groundwater Tracing Summary Report Section 4 Summary and Conclusions Item 1	The report states that "groundwater from the former sinkhole area on-Site only discharges from New Cricket Spring." The evidence from the tracer study does support the idea that the majority of groundwater is discharged from New Cricket Spring; however, low levels of dye were detected in Cricket Pond which indicates that some groundwater is following other pathways. Therefore, the absolute of New Cricket	

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	Page 24	Spring being the only discharge point is not supported. The evidence does support the statement that, at low flow levels, a majority of the groundwater from the former sinkhole discharges from New Cricket Spring.	
16.	Supplemental Groundwater Tracing Summary Report Section 4 Summary and Conclusions Item 1 Page 24	One of the conclusions from the study is presented as: "1. Groundwater from the former sinkhole area on-site only discharges from New Cricket Spring. Groundwater from this area does not discharge from Cricket Spring, the southeast end of the railroad tunnel, or in the Walnut Creek valley." This conclusion is based on • the mean flow discharge rates from New Cricket Spring recorded during the study period from November 1, 2014, to January 5, 2015, • detection of dye in New Cricket Spring, and • the lack of dye discharge from Cricket Spring. However, more than 55 percent of the dye mass was unaccounted. The mass of dye unaccounted was attributed to immobile porosity, but no analysis of the immobile porosity attribution was presented. The immobile porosity hypothesis is therefore unsubstantiated, and it is not known if bypass flow is occurring at elevations lower than the discharge point of New Cricket Spring, or if there is discharge to depth beneath the former sinkhole. The study did not have adequate monitoring points to evaluate dye flow paths in the subsurface; rather, samples were collected at known points of spring discharge. Overall, the dye study and previous ground water monitoring data provide evidence that New Cricket Spring captures	

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		limited amounts of contaminated ground water leaving the Arkwood Superfund site. It is possible that contaminated ground water is bypassing New Cricket Spring both laterally and beneath the artesian spring. A contaminated ground water capture analysis is needed for the site that provides quantitative evidence that the contaminated ground water leaving the site is captured by New Cricket Spring, or else there should be another way of demonstrating where the contamination is going. At a certain (unknown) threshold water level in the epikarst formation (and consequential high flow rate from New Cricket Spring), the mobile porosity will exceed the elevation of the groundwater divide on the site, with potential contaminant discharge to the adjacent railroad tunnel spring, as has previously occurred. Additional investigative activities should be completed to account for this issue. It would be very useful to conduct a dye test in concert with peak discharge colloidal sampling event to evaluate whether or not there is bypass groundwater flow or discharge to depth in the Karst system. The testing and sampling should include subsurface monitoring points (i.e., wells) to evaluate if flow is bypassing New Cricket Spring or there is vertical discharge to deeper parts of the karst system.	
17.	Supplemental Groundwater Tracing Summary Report	The report indicates the fate of the dye is either: (1) that it was captured by the New Cricket Spring; or, (2) that it was “detained in the non-mobile porosity of	

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	Section 4, Summary and Conclusions Item 6 Page 25	the epikarstic aquifer." Dye transport into immobile pores could take months and years. But in this case, the tracer test lasted 7 weeks and peaked at the New Cricket Spring within 8-16 hours of injection allowing limited time for diffusive transport. No data or information was provided to suggest that the unrecovered dye could have bypassed the New Cricket Spring. It appears that the hydrologic conceptual model suggested in this report is that all the ground water associated with the western portion of the site, and possibly all of the ground water underlying the site, is captured by the New Cricket Spring. This does not seem to be justified. Based on the physical properties of PCP (density, solubility in water, and increased water solubility with increased pH in karst terrain), it appears that a large volume of this contaminant may be stored within the epikarstic aquifer, and it would be likely to be discharged in response to fluctuating groundwater levels indefinitely. The detections of low levels of introduced dyes in Cricket Pond indicates that other pathways from the sinkhole area are possible. Due to various lines of evidence, a direct conduit between the sinkhole and the New Cricket Spring has been established. At the outset of the tracer test, it was unclear whether the spring would fully capture the entire mass of tracer injected into the sinkhole area. Based on the results of these tracer tests, it does not appear prudent to conclude that the New Cricket Spring captures all the contaminated ground water passing from the sinkhole area. It would be	

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		informative to inject tracer dye where other waste management activities and/or former process areas were located, not just the sinkhole area. As it is, conclusions are not possible regarding the extent to which New Cricket Spring captures contaminated ground water passing through other areas of the site. A more extensive investigation should be planned to consider what happens when the flow rates are significantly higher than those tested in this study. Potential high-flow discharge points (e.g., New Cricket Spring and the railroad tunnel discharge) should be sampled and tested for both tracer dye and for dioxin concentration in groundwater.	